FRED Reports

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SOCKEYE SALMON *ONCORHYNCHUS NERKA* FRY

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William J. Hauser
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July 1985

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ABSTRACT

Sockeye salmon, *Oncorhynchus nerka*, fry from two test lots with excised ventral fins were examined for up to 15 months to evaluate the rate of regeneration of these fins. The rate of regeneration was rapid. Only 15% of the fin clips of one test lot and 60% of the other test lot were considered to be valid 12 months after the fins were clipped. Fortunately, a trained observer would probably recognize most of these marks.

For one test lot, approximately 3% of the clipped fins were completely regenerated after 12 months. For the other test lot, 23% of the clipped fins were completely regenerated after 15 months.

The mark-loss rate depends on the marking technique or on the size of the fry when marked, or both. If fin excision is used to mark fish, the marking procedure must be strictly supervised. Quality must be emphasized more than quantity.

Key Words: Regeneration, sockeye salmon fry, fin-clipped.

INTRODUCTION

During studies of fin-clipped sockeye salmon, *Oncorhynchus nerka*, fry in Tustumena Lake and smolts in the Kasilof River, fewer fin-clipped fish were caught than expected. This may have resulted from poor survival of hatchery fish, poor survival of fin-clipped hatchery fish, regeneration of clipped fins, or some combination of these factors.

Chadwick (1966) presented a summary of evaluations of fin regeneration among salmonids, including studies of salmon fingerlings. Typically, regeneration was rare for most fins (usually 5% or less), but some authors reported considerable incidence of fin regeneration; e.g., up to 34% for the pelvic fin. In some cases, fin regeneration could have a significant impact on the interpretation of study results. In Alaska, Dudiak (unpublished data) has reported a mark loss of up to 70%, which may include clipped-fin regeneration, among pink salmon, *Oncorhynchus gorbuscha*; Blackett (personal communication), however, did not believe that clipped-fin regeneration contributed significantly to the loss of marked fish in another pink salmon study.

The purposes of this study were to evaluate the incidence and rate of regeneration of clipped fins of sockeye salmon fingerlings and to explain the loss of marked fish from a population. Some of the experimental design included in this study was necessary to accommodate another simultaneous experiment not discussed in this report.

MATERIALS AND METHODS

Test Specimens

There were two sources of sockeye salmon fry for this experiment; one came from a United States Fish and Wildlife Service (USFWS) fisheries laboratory population that originated from the Russian River. These were incubated, hatched, and held continuously in the USFWS laboratory in Anchorage. When their fins were clipped, these fish averaged 35 mm in length (FL) and 0.39 g (1150/lb) in weight. The other source of fry was from eggs taken in 1980 at Tustumena Lake. These fish were hatched at the Kasilof Hatchery. When their fins were clipped, these fish averaged 27 mm in length (FL) and 0.18 g (2500/lb) in weight.

Fin Clipping

The fins were excised using microsurgical scissors under an illuminated magnifier. Each fish had either its right or left ventral fin removed. The Russian River fry were clipped specifically for this experiment on 15 April 1981 at the USFWS laboratory in Anchorage. They were clipped by inexperienced fin clippers, who were closely supervised by an experienced fin clipper. The Kasilof Hatchery fry were clipped at Kasilof Hatchery by an experienced fin-clipping crew, under routine supervision, between 19 May and 12 June 1981. After the Kasilof Hatchery fish were marked, they were transported to the USFWS laboratory on 16 June where they were held for the duration of the experiment.

Experimental Design

In the laboratory, two troughs were loaded with two lots of approximately 600 fry each from the Russian River stock, and two troughs were loaded with two lots of approximately 600 fry each from the Kasilof Hatchery stock. Each trough had a divider separating the fry into right- and left-ventral fin-clip groups (Figure 1); thus, each of the two fin clips used in the experiment had two replicates for each source of salmon fry.

Data Collection

The first observations were made 1 month after the fish were marked; then, data were collected and observations were made for both stocks after approximately 2, 3, 4, 9, and 12 months. The final observations for the Kasilof Hatchery stock were made after 15 months. Usually, for each observation period, fin clips from 50 fish from each replicate were evaluated; however, on three occasions fewer fish were examined: twice to utilize fish that had died and once because only 44 fish remained in one test lot for the last set of observations.

During each data-collection period, fish were selected at random from the troughs, and the clipped fin of each fish was examined with the aid of a dissecting microscope. During the last data collection period, however, the dissecting microscope was not used. Here it was our intent to make the observations without the aid of magnification to simulate conditions under which smolts are observed for clipped fins in the field projects. After 3 months, some fish died when the water control system failed. One replicate of the Kasilof River stock was lost.

Each observation was based on a subjective scoring system outlined in the Fisheries Rehabilitation, Enchancement and Development (FRED) Division Mark-Tag Manual for salmon (Moberly et al. 1977). To obtain the score, the fin is conceptually divided into five zones. Each zone receives a letter designation of "A" through "E" (Figure 2). A clip falling within a particular zone is given that letter score. This is a subjective technique, but with experience, consistency can result.

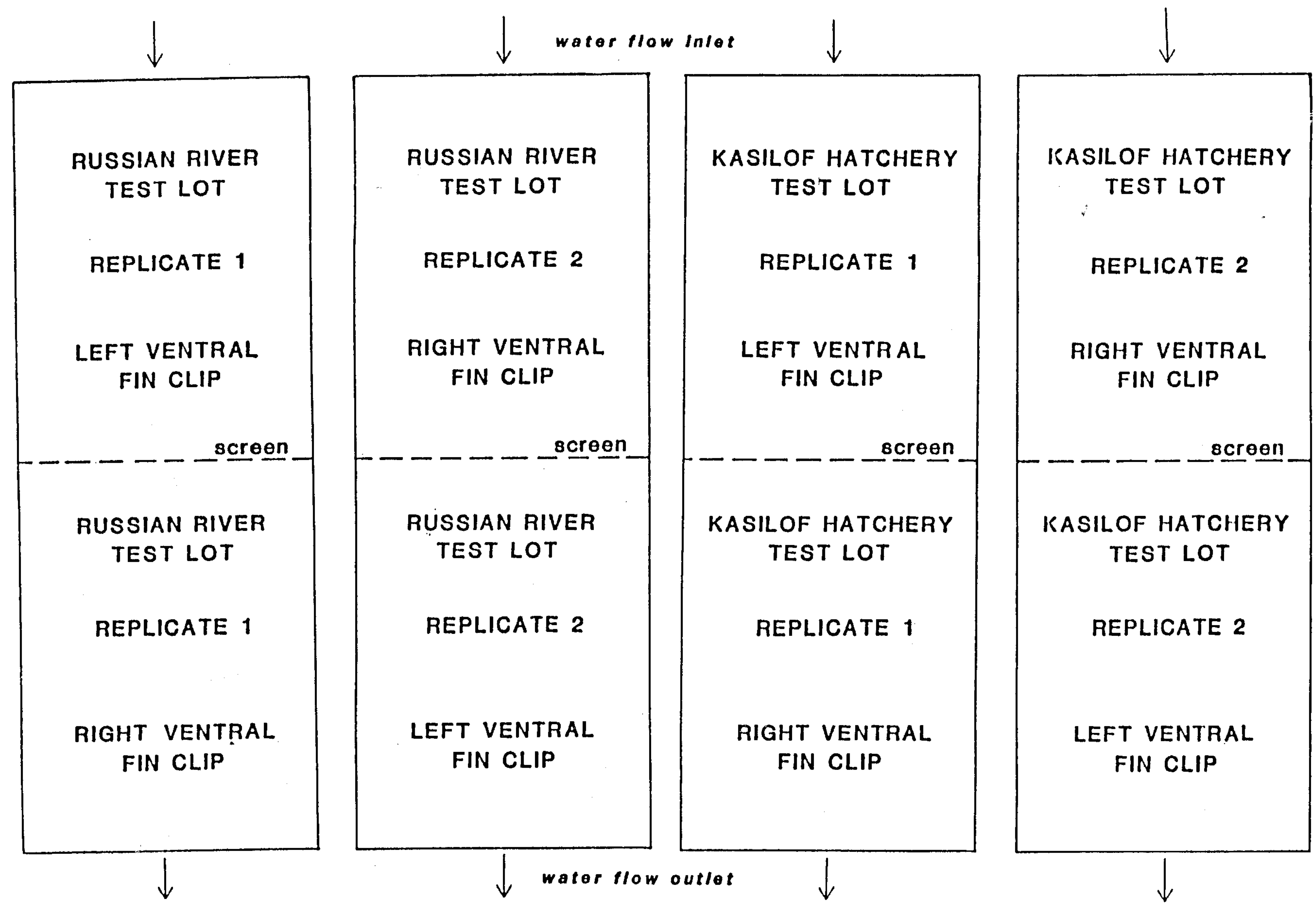

Figure 1. Arrangement of test specimens in laboratory raceways.

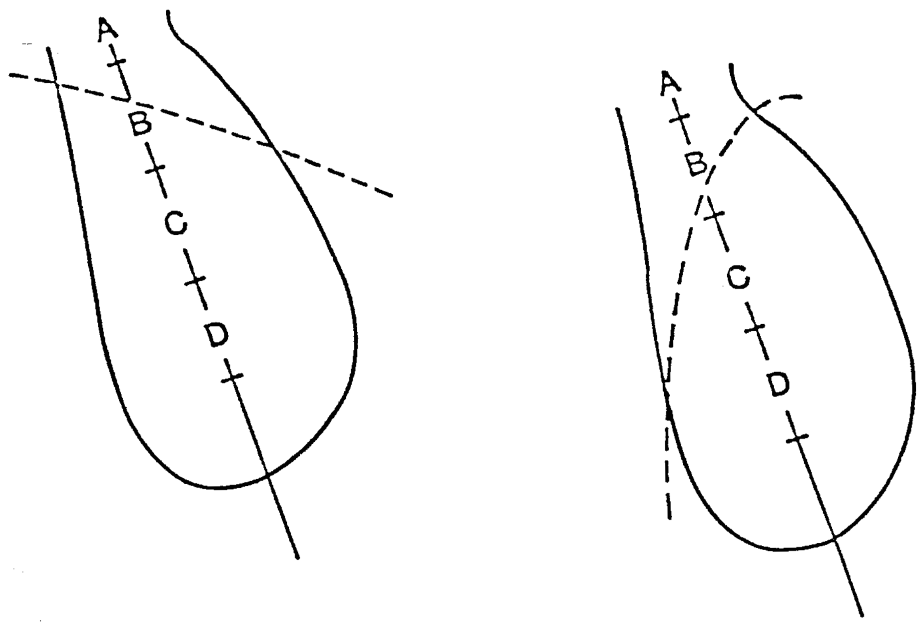

Figure 2. Scoring system to rate the quality of a clipped fin. Clips following the dashed lines are both in the B zone (from: Moberly et al. 1977).

During the last data collection period, a judgment was made if the mark would have been recognized under field conditions as a valid fin clip. We assumed that clipped fins with an "E" score would not be recognized as a valid fin clip, and the fins were considered regenerated.

Data Analysis

The subjective nature of the assignment of a mark to one of several clip zones makes those marks that are borderline between two zones a problem that is difficult to deal with consistently. Although the grading of clips in this experiment was performed by one person, it is possible that some samples were graded differently than others. It is particularly difficult at times to distinguish between A- and B-zone clips. Since A- and B-zone clips are not discounted in standard practice (Moberly et al. 1977), we felt that the combination of all A- and B-zone clips into a single "A+B" zone prior to analysis would minimize problems associated with assignment of a mark to the A or B zones and also function as an index of the highest quality marks. Therefore, the proportion of marks within the A+B zone for each sample date was calculated; then, a series of chi-square tests (Fleiss 1981) was used to determine if there were differences between replicates in proportions of fry with A+B-zone clips. Where no significant differences between replicates were found, data were combined in subsequent analyses that evaluated changes in the proportion of A+B-zone clips over the duration of the experiment.

Finally, the percentage of totally regenerated clipped fins for all lots from each stock was calculated from the observations made 12 months after the fin clipping.

RESULTS

Russian River Sockeye Salmon

Results of the chi-square tests demonstrate that for each date the data of both replicates of the Russian River test lot may be combined for the left-ventral group (Appendix Table A-1) and for the right-ventral group (Appendix Table A-2). The results of the chi-square test for the 9 June left-ventral group were misleading, however, since the frequency of one class was less than 5. Fleiss (1981) stated that if frequencies of any class are small (i.e., less than five), then it may not be accurate to base the significance tests on differences in proportions of the chi-square distribution.

After combining data for replicates within a fin-clip group (i.e., left or right ventral), chi-square tests were used to test for statistically significant differences in the proportion of A+B-zone clips between fin-clip groups for each sample date. For each date sampled, except 23 April, there were no significant differences in the proportion of A+B-zone fin clips between fin-clip groups (Appendix Table A-3). For the 23 April sample date, there was a significant difference in the proportion of A+B-zone clips ($P<.05$), but the 23 April fin clips were graded without use of a microscope. The majority of the results indicate that the proportion of A+B-zone clips was not related to whether the fin removed was a right or left ventral.

After pooling the data from both fin-clip groups (right or left ventral) on each sample date, except 23 April, we proceeded to test for a significant effect of date on the proportion of A+B-zone marks. The results ($X^2 = 123.9$, 4 df) demonstrated that there was a significant ($P<.001$) decrease in the proportion of A+B-zone clips over time: from nearly 90% to 60% 8 months after clipping (Figure 3). The proportion of A+B-zone fin clips remained approximately the same after 4 additional months, but since the proportion of left-ventral A+B-zone fin clips differed significantly from the proportion of right-ventral A+B-zone fin clips (Appendix Table A-3), the 23 April data could not be pooled nor included in the above analysis.

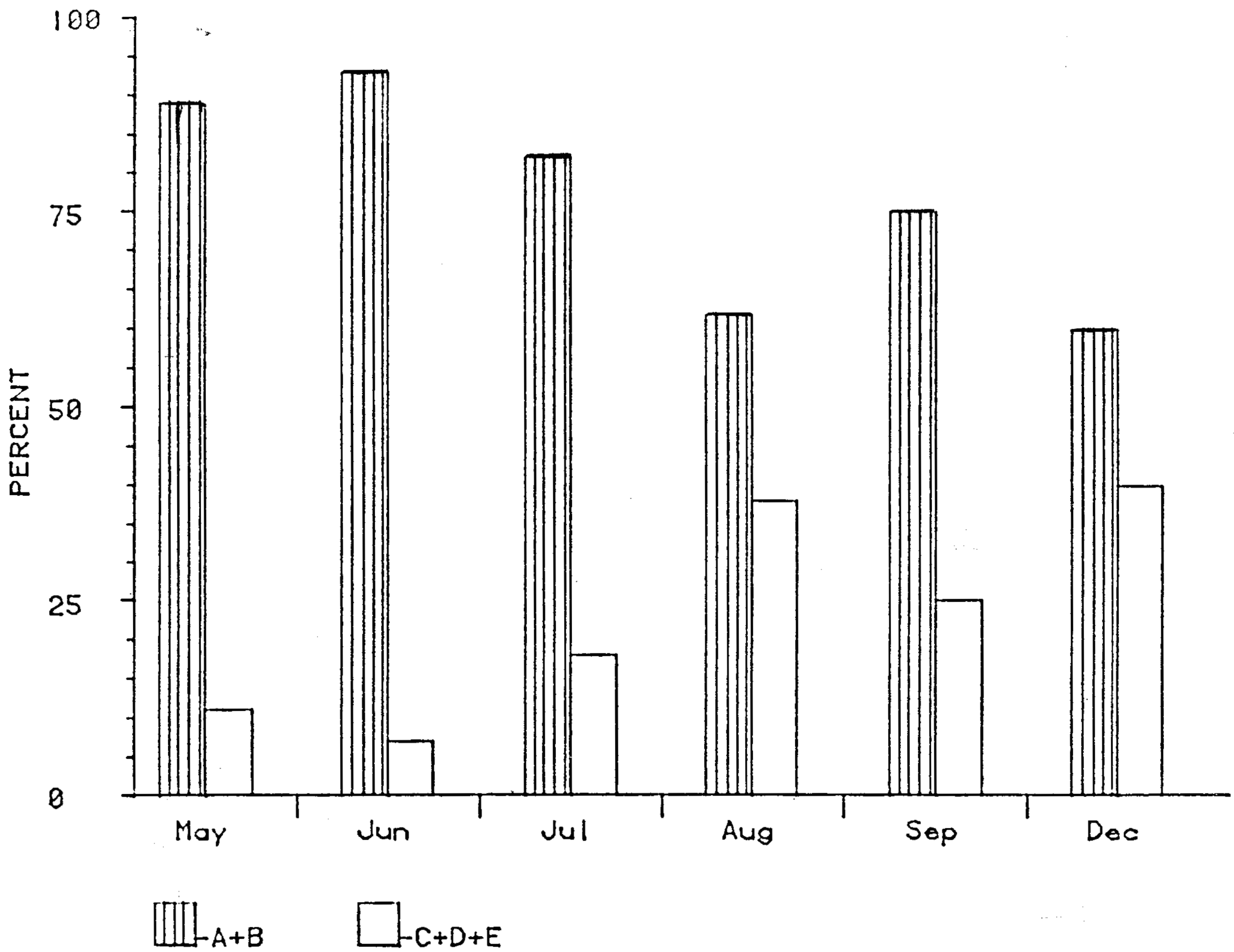

Figure 3. Percentage of A+B and C+D+E fin clips in the Russian River test lot of sockeye salmon fry with both replicates and both right and left ventral fin clips combined.

Kasilof Hatchery Sockeye Salmon

Since both replicates from the Kasilof Hatchery test lot for each fin clip (right or left ventral) were not sampled on all dates, only data from one replicate for each fin clip was used in the analyses. For five of six sample dates tested, the proportion of A+B-zone clips did not differ significantly between right- and left-ventral clip groups (Appendix Table A-4).

After pooling data for right- and left-ventral fin-clip groups from the above five dates, a chi-square test indicated a significant ($P<.001$) decline in the proportion of A+B-zone clips over time ($X^2 = 227$ with 4 df) and a rapid decrease within 3 months (Figure 4).

Regeneration

After 12 months from the time of fin clipping, we observed that 2.1% (0.4 - 8.2%, 95% CI) of the LV and 4.0% (1.3 - 10.5%, 95% CI) of the RV clipped fins of the Russian River test lot were considered regenerated. After 12 months from the time of fin clipping, 23% (15.4 - 32.7%, 95% CI) of the clipped fins of the Kasilof Hatchery test lot were considered regenerated.

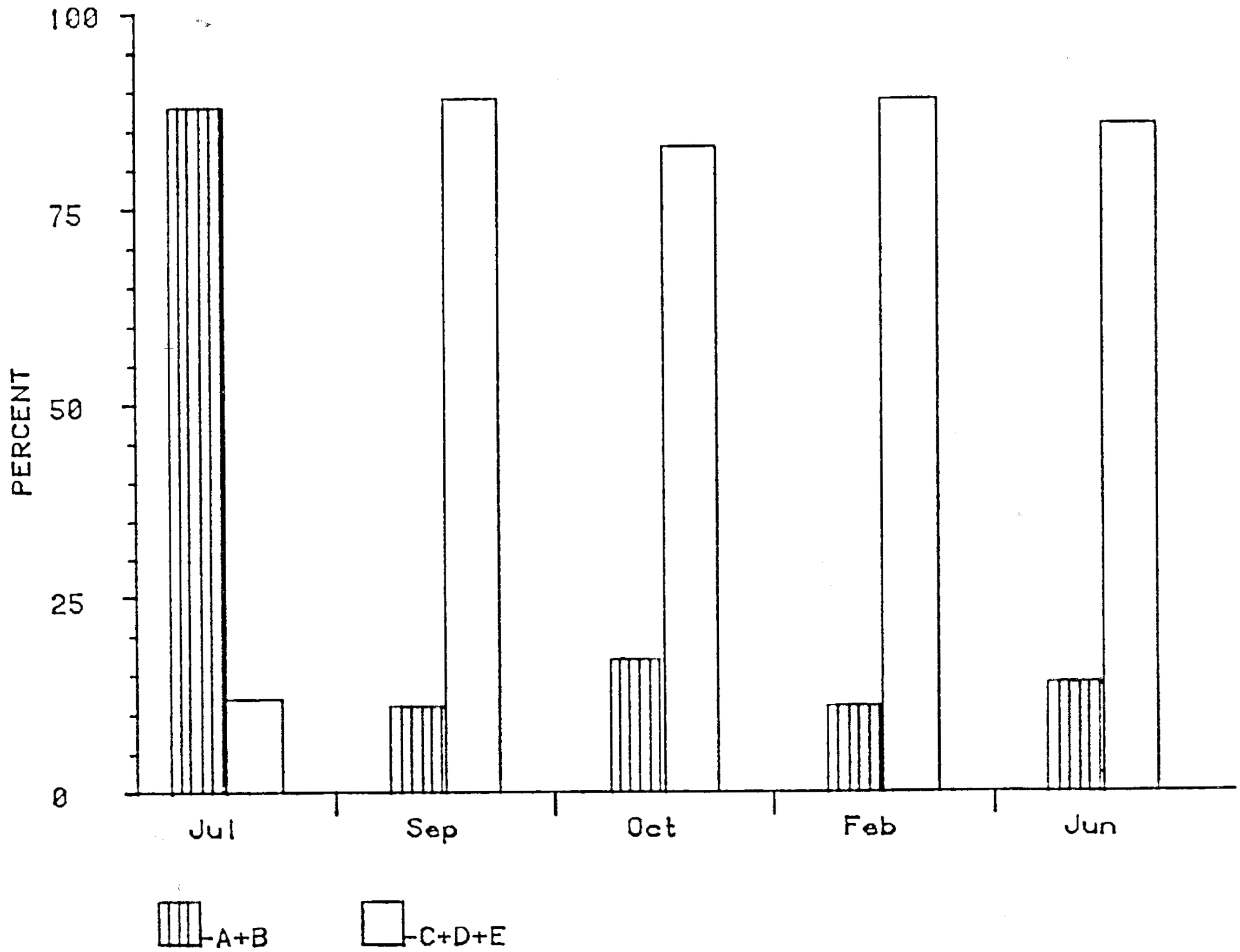

Figure 4. Percentage of A+B and C+D+E fin clips in the Kasilof Hatchery test lot of sockeye salmon fry with right- and left-ventral fin clips combined.

DISCUSSION

For both of these test lots, there is a substantial loss of A+B-zone clips within a brief period of time. This mark-loss rate is largely attributed to regeneration, though it could have resulted from differential mortality of fish with A+B-zone vs. C+D+E-zone clips. This experiment was not designed to evaluate differential mortality due to clipped fins, and dead fish were not examined to evaluate the quality of their fin clip. Chronic mortality, however, was negligible.

Applied literally, these data imply that if only A+B-zone fin clips are considered valid fin clips, the mark loss due to regeneration for the Russian River test lot would be 40% in 8 or 12 months and 85-90% within 3 months for the Kasilof Hatchery test lot. Fortunately, a trained observer may often recognize many of the C+D+E-zone clips (particularly C-zone clips) as valid marks. Usually, as a clipped fin regenerates, the rays are deformed, or the margin of the fin will be truncated or "clubbed" (Stuart 1958). The patterns of regeneration we observed were similar to those he described (Figure 5). Note especially, the slight difference in size and shape of the regenerated RV fin and the growth pattern of the fin-rays in Figure 5E. Our data, however, demonstrate that fin regeneration is rapid and that it may be an important component of lost marks from a population. In addition, it is clear that observers must be trained to recognize fins with regeneration and count them as valid marks.

One year after the fins were clipped, the proportion of total regeneration was substantial for the Kasilof Hatchery lot. Our observations, however, were made in a near-ideal setting, and all fish examined had been fin clipped; whereas, under typical field conditions, the setting is less than ideal, and only a small proportion of the fish examined are expected to have been marked.

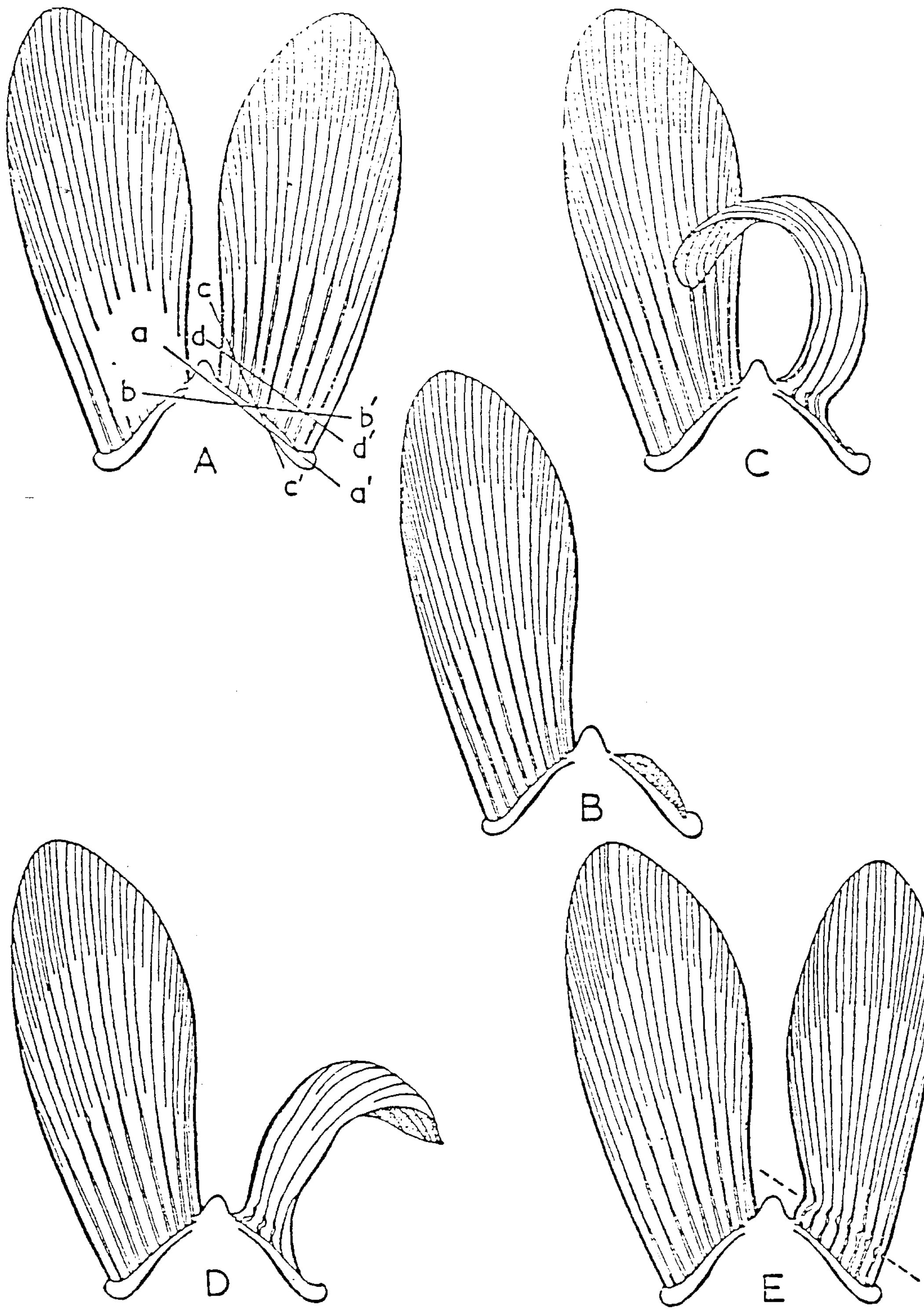

Figure 5. Fin regeneration resulting from various clips. Clip a-a' in Figure 5A resulted in the pattern in Figure 5B. Clips b-b', c-c', and d-d' in Figure 5A resulted in the patterns in Figure 5C, D, and E; respectively (from: Stuart 1958).

Mark loss through regeneration may be substantial, and most studies of salmon have reported regeneration of pelvic fins at approximately the same rate we observed (Chadwick 1966). Weber and Wahle (1969), however, reported an even greater mark-loss rate, including both regeneration and other mortality, of 39% from fingerling to adult.

It is also clear that the mark-loss rate differs depending on the marking technique or the size of the fry when marked. These factors were not included in the experimental design (we attempted to minimize these differences), but the Russian River test lot of fry was slightly larger than the Kasilof Hatchery test lot of fry when marked, and the marking procedure for the Russian River test lot was more intensively supervised than the Kasilof Hatchery test lot. This demonstrates the importance of good training and supervision of marking crews as well as the importance of including good quality control procedures in the marking program.

Without even considering differential mortality of fin-clipped fish due to competitive disadvantage and predation, it is apparent that fin clipping is an imperfect technique for marking fish. We wholeheartedly support investigations of alternative marking techniques as well as further studies to elucidate the effects of fin clipping. Where fin clipping is the only marking technique available, we recommend that the procedure be strictly supervised and that <u>quality</u> be emphasized more than <u>quantity</u>.

ACKNOWLEDGMENTS

Bob Och and personnel from Kasilof Hatchery provided one test lot of marked fish. Edna Shambo supervised the fin clipping for the Russian River test lot of fish, and Dave Waite took care of some logistical needs. Apparatus for this study was housed in the United States Fish and Wildlife Service laboratory in Anchorage. We thank Dick Wilmot and personnel from the Fish and Wildlife laboratory for providing one test lot of fish, space, feed, equipment, and caretakers, and to Sid Morgan and Ken Leon for editing the manuscript.

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APPENDIX A

Table A-1. Proportion of A+B zone left ventral fin clips in both replicates of the Russian River sockeye salmon fry and results of chi-square analyses to test if the proportion of A+B-zone clips differed between replicates.

Sample date	Replicate 1-1	Replicate 2-2	X^2	df	Significant difference	P
05/12/81	0.88	0.84	0.33	1	no	>0.50
06/09/81	1.00	0.92	4.17	1	yes A/	<0.05
07/07/81	0.84	0.88	0.33	1	no	>0.50
08/10/81	0.58	0.60	0.04	1	no	>0.75
09/30/81	0.68	0.84	2.37	1	no	>0.10
12/23/81	0.54	0.60	0.37	1	no	>0.50
04/23/82	0.72	0.73	0.006	1	no	>0.90

A/ No C+D+E zone clips in one of the replicates.

Table A-2. Proportion of A+B-zone, right-ventral fin clips in both replicates of the Russian River sockeye salmon fry and results of chi-square analyses to test if the proportion of A+B-zone clips differed between replicates.

Sample date	Replicate 1-1	Replicate 2-2	X^2	df	Significant difference	P
05/12/81	0.94	0.92	0.54	1	no	>0.25
06/09/81	0.90	0.90	0	1	no	>0.99
07/07/81	0.76	0.80	0.23	1	no	>0.50
08/10/81	0.74	0.56	3.56	1	no	>0.05
09/30/81	0.66	0.79	1.28	1	no	>0.10
12/23/81	0.46	0.52	0.36	1	no	>0.50
04/23/82	0.52	0.64	1.48	1	no	>0.10

Table A-3. Proportion of A+B-zone fin clips in both treatment lots of Russian River sockeye salmon fry with both replicates pooled and results of chi-square analyses to test if the proportion of A+B-zone clips differed between treatment lots.

Sample date	Fin clip treatment		X^2	df	Significant difference	P
	RV	LV				
05/12/81	0.92	0.86	1.84	1	no	>0.10
06/09/81	0.90	0.96	2.77	1	no	>0.05
07/07/81	0.78	0.86	2.17	1	no	>0.10
08/10/81	0.65	0.59	0.76	1	no	>0.25
09/30/81	0.71	0.75	0.24	1	no	>0.50
12/23/81	0.49	0.57	1.29	1	no	>0.25
04/23/82	0.58	0.72	4.38	1	yes	<0.05

RV = Right ventral
LV = Left ventral

Table A-4. Proportion of A+B-zone fin clips in both treatment lots of the Kasilof Hatchery sockeye salmon fry with both replicates pooled and results of chi-square analyses to test if the proportion of A+B-zone clips differed between treatment lots.

Sample date	Fin clip treatment RV	LV	X^2	df	Significant difference	P
07/07/81	0.88	0.90	0.10	1	no	>0.75
08/10/81	0.78	0.48	9.65	1	yes	<0.005
09/15/81	0.10	0.12	0.10	1	no	>0.75
10/14/81	0.22	0.12	1.77	1	no	>0.10
02/18/82	0.12	0.10	0.10	1	no	>0.75
06/01/82	0.10	0.18	1.33	1	no	>0.25

RV = Right ventral
LV = Left ventral